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ABSTRACT

In this paper the theory that human thinking proceeds according to the computer model, or symbol manipulation, is reviewed and challenged. The research used as subjects five highly rated tournament chess players who "thought aloud" during a chess game to provide tape recorded protocols of decisions made while playing. These protocols were then analyzed phenomenologically in three steps. Results are presented for nine specific issues in which the phenomenological approach differs from computer simulation programs: the look ahead function, purposiveness, goal seeking, memory, overall sense of the task, level of knowing, role of experience, expectations, and opponent's style. The most significant general divergence between the two methods is noted as the computer's ability to thematize millions of possible subsequent combinations of moves while a person can thematize only a few dozen possibilities. The paper concludes that, given the divergence between the two models, a descriptive method can be useful for the psychology of thinking. Results are followed by a list of references. (ABB)

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FINDINGS AND IMPLICATIONS OF A DESCRIPTIVE APPROACH TO THINKING

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Findings and Implications of a Descriptive Approach to Thinking

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Good morning.

I've been researching thinking as it is exemplified during chess playing for a decade now. It's been quite a fashionable context for research ever since Newell (1955) identified chess as the "type case" for the demonstration of computer modeling in psychology. But my own research takes a different approach than that. I studied thinking in chess by means of a descriptive, and specifically a phenomenological, methodology. This difference is similar to the contrast between Neissr's psychology of memory and that of the computer modelers. Neisser (1982) himself characterizes this difference as that between the high road of formalism and the low road of real life. He points out that psychology has traditionally taken th high road, but argues it is time for us to try the low road. I agree with him, and would go on to argue that phenomenological methodology provides a fine means of traversing this low road. I'd like to use this opportunity to present some findings illustrating its advantages in doing so. Therefore, I've structured my presentation as a dialogue with the omputer simulation approach, and specifically with the work of its founders, Allen Newell and Herbert Simon. They've earned a place in psychology's Hall of Fame for their pioneering efforts in establishing a paradigm they call human information processing, and I unequivocally acknowledge its pre-eminent status as the wellspring of the contemporary cognitivist revolution in psychology. Let me take a moment to briefly summarize their approach to thinking.

Their basic premise is that the person, like the computer, is an

information processing system, whose thinking can therefore be demonstrated with computer simulation models (Newell, Shaw & Simon, 1958a, 1958b; Newell & Simon, 1961, 1972; Simon, 1978, 1979; Simon & Newell, 1964, 1971). According to their view, the computer simulation program provides a model of how thinking proceeds (Newell & Simon, 1972, p. 5). Hence their fundamental methodology has been to design computer programs capable of simulating human performances in order to demonstrate what it requires. Their model yields the conclusion that thinking is essentially symbol manipulation in the same sense that computer processing is. In other words, thinking is viewed as a series of elementary or primitive processes, combined serially according to explicit, pre-determined rules, each process of which is a formally definite operation for the manipulation of information in the form of elemental and discrete symbols.

With this point, I must pause to interject a paranthetical comment. Occasionally, an information processing psychologist will argue that this view of thinking is not really based on computer models, but that the computer is simply a means of testing the theory, i.e., to prove its sufficiency, or even that the computer is merely a metaphor. Fortunately, Simon and Newell had more intellectual honesty concerning this issue; or perhaps they were simply more naive concerning the ultimate success of computer models. At any rate, their publications are sprinkled with assertions that the computer model's program <u>is</u> the theory (Newell & Simon, 1963, p. 279), that a computer simulation is <u>not</u> a metaphor, but a precise model (Newell & Simon, 1972, p. 5), and indeed that the information processing approach <u>depends</u> on the assumption that computers <u>are</u> organized "in the image of man" (Simon, 1969, p. 22). This assumption is one they have consistently made. For example, after identifying the computer as a "Turing machine" (i.e., named after the inventor of the modern digital computer), and one that can be programmed to imitate human thought, Simon and Newell (1963, p. 101) add "lest this statement depress my listeners, let me

observe again that the human being is a Turing machine too."

Frankly, this assumption necessarily underlies the use of the computer as a demonstration of the sufficiency of information processing theory. It is no longer enough simply to assert that if a program contains all of the statements required for a computer to play chess, then the program can be taken as a simulation of thinking. The criterion that similarity of results alone could establish the validity of the computer model was eventually acknowledged to be inadequate, after it was pointed out that similar results were no guarantee that they had been attained in a similar manner (de Groot, 1978, pp. 387-388; Gunderson, 1964; Hearst, 1967, p. 32). For example, airplanes can fly, but that result is not a simulation of birds flying because they do not fly in the same way (Simon, 1980, p. 76-77). Most information processing theorists now admit that it is the processes themselves that must be simulated, and not merely the results (Simon & Newell, 1971, p. 147; Simon, 1980, pp. 76-77). But this requirement led to an additional problem: the lack of data on how human thinking actually proceeds. This question is so problematic because the information processing approach sought to simulate thinking before it understood thinking, presuming to know the very phenomenon that needed to be disclosed.

Some information processing researchers have attempted to fill this gap by searching for similarities between the steps taken by computer simulation programs and protocols spoken by human subjects engaged in solving the same problem (Newell 1977; Newell & Simon, 1961, 1972). Such comparisons can be quite ambiguous because of the differences between the computer language of the simulation program and the ordinary language used by the human subject (Boden, 1972, p. 111; Simon & Newell, 1971, p. 148; Kendler, 1981, pp. 362-363). To insure fidelity under these circumstances, a rigorous analysis of the human protocols in their own right should be the necessary pre-requisite. But this has not been done. Instead information processing preconceptions have biased

these comparisons in ways that can be severely criticized (Frijda, 1967; Wilding, 1978, p. 171). Even Newell's (1977) more thoughtful effort to specify a means of protocol analysis that would be helpful "for developing theory rather than for validating theory" remains faithful to inferred information processing preconceptions, as its aim is to identify the presumed elemental "operators" applied to a presumed "problem space" to incrementally change a presumed "state of knowledge."

This same drawback still applies to Ericsson and Simon's new book on protocol analysis. They acknowledge that their specifications for the analysis of verbal protocols require the assumption that cognition is "a sequence of internal states successively transformed by a series of information processes" (Ericsson & Simon, 1984, p. 11). They go on to justify this assumption by stating that "information processing models that incorporate these features have been constructed in the form of computer programs, and these have been shown to produce a variety of behaviors" (Ericsson & Simon, 1984, pp. 11-12). Hence, again, the basic question is simply presupposed, and this presumption is taken as support for the theory.

On the basis of such presuppositions, Newell and Simon have constructed an information processing model of thinking, which posits several basic cognitive operations, essentially similar to their computer simulation programs. The results of my own descriptive study of chess playing disclosed thinking differently with regard to specific dimensions posited by the computer model. I'd like to present these specifics, demonstrating in each case the contribution of the phenomenologically based findings. First, however, a brief word needs to be said about the method I used.

METHOD

Five highly rated tournament chess players were used as subjects in this study. Each subject played one game of chess, having the white pieces (and so

making the first move), against an assistant of the researcher. Each subject played against a different assistant, matched as closely as possible with the subject's own level of skill. Before the game began, the subject was given a page of written instructions to read and an Informed Consent form to read and sign. These specified that the subject was to "think out loud as completely as possible all of the thoughts you are having throughout the game... exactly as they occur to you." While the game was in progress, the subject's entire thinking aloud was tape recorded. The opponent was prevented from hearing the subject by wearing headphones through which continuous music was played.

These, the tape recorded protocols were then transcribed and a portion of each transcript was set aside for in-depth analysis. The portions to be analyzed in-depth were selected from points at which the games were still relatively evenly balanced, and leading toward an important turning point. (The interested reader may find these transcripts in their entirety in Aanstoos, 1983).

Next, these protocls were anlyzed by means of phenomenologically. In such an analysis "the task of the researcher is to let the world of the describer... reveal itself through the description" (Giorgi, 1975b, p. 74), in order to remain faithful to the phenomenon as it was lived. This aim is fulfilled by engaging the naive descriptions and discerning their psychological sense, through a three-step process of bracketing, intuiting, and describing.

In the first step, the researcher brackets, and makes no use of, theoretical perspectives in order to take up the perspective of the experiencing subject. By deliberately avoiding concentrating attention on any particular pre-determined aspect, the researcher is able to escape the danger of finding only what one expects to see. Instead, one adopts an attitude of "open-ended presence to the phenomenon that is unfolding" (Giorgi, 1976, p. 313). Concretely, this step involved the resarcher's empathically immersing himself in

the world of the thinking subject, by reading the transcript several times to get a sense of it as a whole, attuned not merely to the linguistic content, but to the experience of the subject.

The second step involved grasping the psychological meanings through a discernment of the essential significance of the subject's experience. Such essential meanings are made explicit by way of identifying meaning units, specifying their central themes, and then articulating their psychological sense or meaning.

In the third step, the meanings achieved were organized into a systematic structural description in order to grasp the inter-relations of the essential meanings through their coherence (Giorgi, 1975a, 1975b; and Wertz, 1983). This procedure consisted of two phases. The first task was to describe the situated or individual structure for each of the empirical cases. These ideographic descriptions remained anchored in the concrete experience of the particular subject, and thus were the systematic structural statements of the essential psychological significances that were grasped in the preceding step.

Then, the second task of this operation was to interrogate those individual structures in order to proceed from them to a description of the structural significance of thinking in chess in general, by retaining those features that were essentially invariant across the particular cases. In other words, the analysis proceeded from the individual to the general by means of its articulation of the "essential generality" of each particular instance examined.

RESULTS

Now I would like to present my results in relation to computer models of thinking in chess. I'll be comparing my findings especially with Newell and Simon's GPS program, but also with others they've worked on with colleagues, such as the MATER, PERCEIVER, and BELLE programs. I've selected nine specifc issues in which my results differ from these computer simulation programs. I'll

review each of these issues in turn. Before discussing the specifics, however, there is first one general difference important to note. In selecting a move, a person thematizes at most a few dozen possible subsequent combinations of moves. Computer models, on the contrary, thematize thousands, hundreds of thousands, and even millions. In fact, the better the computer's performance, the greater its search. Obviously, person and computer are proceeding differently, even if both select the same move in the end. Some information processing theorists hold onto the hope that this discrepancy is illusory, by insisting that the person is actually secretly calculating all of these possibilities as well. Most, however, admit this difference, and even acknowledge that it is a serious anomaly, but have no means of reconciling it. I'd like to suggest that the specific issues I'll summarize next may be helpful in comprehending the basis for this general anomaly.

Alright, so now on to the specifics.

1. Look ahead Computer models posit a look ahead function that proceeds in a linear, move by move counting out fashion, to a predetermined depth. The results of my study also include data in which such move by move sequences are taken as objects of thought. However, in contrast with computer models, such move by move sequences were found to be always embedded within thinking's overarching contact with an implicit sense of the flow of the game as a whole. This unitary relation of the particular move to the flow of the game was achieved by thinking through a sense of 'initiative' as a telic characteristic. And it is this unity that guides thinking's looking ahead, even in the absence of any counting out sequence. For example, thinking about the consequences that a move in the middle game had for the endgame was typical for the subjects, yet that is something no model based on a sequential look ahead can simulate. A specifc example is S.1's having refrained from moving his queen at one point based on thinking that he would need it where it was to counteract an attack on

that side of the board at some as yet indeterminate point in the future. That looking ahead involved no specific sequence of counting out at all, but was based on the sense that the initiative was changing toward his opponent. In other words, the results show that the information processing model's problem cannot be resolved simply by lengthening its look ahead to a farther depth. Rather, they indicate that thinking looks ahead in an essentially different way.

2. Purposiveness Compputer models posit predetermined heuristic rules as guiding thinking to certain moves and not others. The results of my study do show that general principles are involved in thinking in chess. However, rather than simply adhering to predetermined guidelines as sheer facticities, thinking takes them up as guidelines, as objects of thought. As such they are questioned, as possibilities. For example, S.4 followed the principle of posting a knight on the sixth rank when he had the opportunity, as an explicit following of a maxim that it is advantageous to do so. But the maxim itself was thematic as a question, and following it meant extending that questioning to the position on the board. In other words, the maxim did not serve to conclude thinking, but to evoke it. So, even when followed, maxims serve as signifiers rather than as rigid rules. Perhaps an even more clear example of this difference between thinking's flexibility and the model's rigidity occurred in those instances when thinking took up again as questionable the very possible moves it had already rejected. For example, S.1 repeatedly reconsidered playing "pawn takes pawn" after having decided against it "on general principles." Such data provides ample support for the distinction that thinking determines the applicability of guidelines within the context of the game or situation, in contrast to the predetermination that is made for the computer simulation program's heuristics.

3. Goal seeking Computer models represent thinking as serial processing, able to pursue only one goal at a time. The descriptive results are also

revelatory on this point, for they show thinking pursuing a multiplicity of goals simultaneously. More specifically, they show this simultaneity is possible because the goals are related to each other as theme and horizon. For example, S.2's pursuit of the goal of controlling the center was thematic and his goal of maintaining the initiative was horizonal. Both could be pursued simultaneously because of their intrinsic relatedness at a structural level. This finding undercuts Newell and Simon's (1972, pp. 796-797; Simon & Newell, 1971, p. 149) argument against such multiplicity, for they had based their argument on the demonstration that a person cannot do two unrelated tasks simultaneously. This understanding of the structural relatedness of thinking's goals needs also to be distinguished from the computer model's use of goals and subgoals (Newell & Simon, 1972, for example). Such a model achieves a goal by breaking it down into steps, called subgoals, and then establishes subroutines to solve these subgoals one at a time in order to narrow the difference between the present state and the goal state. It would appear that thinking also includes this use of goals and subgoals. For example, S.1 wondered whether to open the long diagonal in order to attain greater offensive threats. To read that as compatible with the computer model, however, is to miss a subtle but important distinction. The difference is that, for thinking, the former goal (in this case, the open diagonal) is not one small step on the way to the latter goal (in this case, greater offensive threats). Rather, the latter, as initiative, is the horizonal meaning of the former. The open diagonal, as theme, is not isolated from its horizon as if it were one step on the way toward something other than itself. Rather it is embedded in that horizon specifically by means of a referential unity of implications.

4. Memory In computer models, memory serves thinking by storing an enormous amount of information in the form of isolated bits. My research showed that memorial objects do indeed serve thinking, but in a much more concise and

organized form. It is concise because memorial objects are taken up as objects of thought only as they are appropriate to the present game. Thinking's capacity to grasp this essential similarity is what enables it to make more limited yet more effective use of memory. The effectiveness of thinking's use of memorial objects is also dependent on another structural difference with the computer model: the memorial objects are recalled as dynamic wholes - for example, S.1's remembering of his previous game against Bisguier. Indeed, it is only because it is recalled as a whole that he can discriminate its essential similarity from other merely incidental simlarities, a distinction impossible for computer models.

5. Overall sense of the task Two related differences may be noted here between computer models and the results of my study. For the model, the chess game is incrementally put together and is evaluated statically. In contrast, thinking is guided by an overall sense of the game which it evaluates dynamically. One obvious way by which that is repeatedly manifested is through thinking's tendency to provoke reorganizations in the subject's perceptual grasp of the position. Chase and Simon's (1973a, 1973b) PERCEIVER program had no such capacity. This overall sense that unites any individual move within the flow of the game is possible because each move refers to a larger whole (the referential unity) and because the shifting balance of offensive opportunities and defensive necessities is itself an object of thought (as 'initiative'). This overall sense is not an artefact of incremental objects but is itself their telic strucutre. Similarly, it is 'the initiative' as an object of thought that founds the dynamic evaluations typical for the subjects. S.1 and S.4, for example, continued to regard their position as superior to their opponents' even while they were down a pawn in material.

6. Level of knowing Computer models function completely on the basis of formal and explicit criteria. The descriptive data, however, reveals that

thinking is guided by a tacit awareness of objects of thought that remain implicit. For example, all of the subjects recognized certain moves as significant even without being able to specify wherein their significance lay. This difference may be most crucial to computer modeling, for it is based on the belief that thinking can be represented as a formal, explicit system. In contrast, the subjects' thinking was guided by the implicit referential significances of the position. An example from the descriptive results is the role that a sense of closure, as an implicit and nonformal characteristic, had for thinking.

7. Role of experience Computer models seek to explain intuition on the basis of stored patterns from previous experience. But, as in the use of memorial objects in general, the elemental and predetermined nature of the program's stored patterns differ from the wholistic and contextually relevant patterns the subjects used from their previous experience. And, with regard to the issue of intuition in particular, analysis of those instances wherein a subject thematized a particular move 'out of the blue' as it were, reveals that it is the thematization as now relevant of a possibility that had already been referred to obliquely. This situating the relvance of a preceding object of thought therefore does depend on previous experience in that the object of thought had been previously experienced implicitly. However, it does not require, not arise from, an array of thousands of elemental and predetermined patterns.

8. Expectations Though absent from computer models, expectations were frequent objects of thought for all subjects. They concerned not only the position (for example: "there's got to be something here though. I just know there's got to be something here" by S.4), but also the opponent's intentions (for example: "after pawn to queen three as I expect him to play" by S.3). These expectations are not inferences or calculations, but the temporal

adumbrations (given through the referential arcs) of 'initiative' as an object of thought.

9. Opponent's style A sense of the opponent's "chess personality" -- likewise absent from computer models -- was a common object of thought for the subjects. The descriptive results reveal that this sense of the opponent emerges in the course of the game. At first, the opponent is grasped almost anonymously, simply as "the opponent." Early thematizations of the opponent are based on the subjects' empathically putting themselves in their opponents' perspective. There is a phase of questioning the opponent's ability by some subjects (notably S.4). Then eventually, the opponent's style coalesces as a specific object of thought. For example, S.1 concluded "now I have some kind of idea of what kind of player I'm dealing with... take everything in sight, especially when you're down in material."

CONCLUSION

Taken in their totality, these differences constitute a significant divergence with the computer model of thinking. The basic conclusion supported by this divergence is that a descriptive method can be useful for the psychology of thinking, and that the door should not be closed to the infusion of findings based upon such a method.

Thank you.

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